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THE ENCHYTRÆIDÆ (OLIGOCHÆTA) OF THE WOODS HOLE REGION, MASS.*

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INTRODUCTION

During the summers of 1915-16, the writer carried on some experimental studies with certain Enchytræidæ (Oligochæta) at

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*Contribution from the Entomological Laboratory, Kansas State Agricultural College, No. 29.

Woods Hole, Mass. Owing to the fact that the known marine species of that locality intermingle in the same habitats, and that some of them have been reported from both fresh-water and terrestial conditions, it was necessary to identify the enchytræids from the various collecting grounds about Woods Hole in order to avoid error in handling immature individuals and to insure accuracy in the identity of the materials used. In spite of the fact that two species occur in great abundance in the environs of Woods Hole and certain other parts of the Atlantic Coast, they have received scant attention from workers in any of the fields of zoology.

The writer wishes to acknowledge indebtedness to Director F. R. Lillie for the privilege of using the facilities of the Marine Biological Laboratory during the time this and other related work was in progress.

ENCHYTRÆUS ALBIDUS HENLE

Previous Records

Four records of this species on the Atlantic Coast occur in the literature. Verrill ('73) was the first to discover it in North America, describing it as *Halodrilus littoralis,* but its identity with *Enchytræus albidus* Henle was later established by Michaelsen ('00, p. 89). Verrill reported it from "New Haven; Woods Hole; Casco Bay, Maine; very common under dead sea-weeds and stones near high-water mark." Smith ('95) made a careful anatomical study of this annelid at Woods Hole, using the name *Enchytræus littoralis* Verrill. He found the specimens extremely abundant in the same kinds of situations described by Verrill. Moore ('05) reported *Enchytræus albidus* very numerous at Woods Hole as well as along the coast from Casco Bay, Maine, to Sea Isle City, New Jersey. He not only found them in the inter-tides zone of the shore but also "in moist spots on farm lands on Martha's Vineyard, where it could readily be introduced in the large quantities of eel grass that are annually spread for fertilizer." He likewise states that "about Woods Hole it also lives in damp, sandy woods and on the shores of fresh-water ponds, especially of one that formerly was connected with the Sound." Passing notice is made of all of the above-mentioned records by Sumner, Osburn, and Cole ('13). Hunt ('15) collected this species "in abundance from the coarse gravel of the tidal zone on the seashore at Cold Spring Harbor, Long Island, New York."

HABITAT

Specimens of *E. albidus* were found in great quantities in several of the protected coves about Woods Hole where the tide casts up masses of eel-grass on sandy or gravelly beaches. They appear to be restricted entirely to the inter-tides zone since no specimens were collected in the comparatively dry sand above the high tide line and none was observed beyond the low tide limit where the sand is constantly covered with water. At low tide, the windrows of eel-grass retain a considerable amount of moisture, thus keeping the underlying sand saturated and protecting it from the heat, light, and drying effect of the summer sun. At high tide, the entire zone occupied by these worms is submerged. They were absent from sandy beaches which lacked the masses of eel-grass, and even when the latter were present, the worms were apparently much reduced in numbers when the sand contained little or no organic debris. In July and August, these enchytræids occur in great numbers on the beach just opposite the Lecture Hall of the Marine Biological Laboratory. The principal features of this habitat are a smooth, sandy-gravelly, gently sloping beach; thick layers of eel-grass on the inter-tides zone at low tide; quantities of fine pieces of coal and cinders mixed with the sand; large amounts of organic matter in various stages of decomposition; and complete protection from wave action. The worms have a rather definite vertical distribution. In the matted eel-grass, they usually occur in very small numbers, but appear in large quantities in the first one to three inches of underlying sand and gravel. Below these depths, the number decreases very rapidly. They show a distinct tendency to accumulate about small rocks and pebbles which are imbedded in the sand so that when such an object is removed, the walls of the cavity are frequently covered with worms.

Several examinations of the various brackish, fresh-water, and moist woodland habitats did not reveal the presence of these enchytræids, although Moore ('05, pp. 394-395) reported them in such places. However, it is very possible that a more thorough search would reveal them under the above-mentioned conditions, since in addition to Moore's record they are definitely known from such habitats in other parts of the world.

Methods of Culture

Specimens were easily kept alive in the laboratory by placing a number of them in shallow stender dishes containing sea water to the depth of about one centimeter, to which had been added pieces of fresh, green eel-grass from the drift on shore. In most of the cultures used by the writer, the eel-grass was partly cleaned by washing and wiping each blade, in order to avoid introducing into the culture an excess amount of the extraneous matter adhering to the eel-grass which interfered with the examination of the cultures for cocoons. All of the cultures were kept covered, some being kept in darkness while others stood in diffuse sunlight. In such cultures, the specimens were active, cocoons were produced, and the mortality was very low, the worms living until the cultures were purposely destroyed, in some cases, after thirty days. Should it be desirable, the water in the cultures can be reduced to the amount necessary only to keep the worms and eel-grass thoroughly moist. Hunt ('15, pp. 496, 501, 503) cultured this same enchytræid for regeneration experiments by placing them "in small sterilized glass bottles, each containing a strip of filter paper and enough sterilized sea water to keep the animals well moistened." He also found that the worms could be kept in such bottles moistened with "fresh water" in which they regenerated as well as in the salt-water environment. It would appear from Hunt's statement of methods that his specimens were not *submerged* and he makes no statement as to the source of the "fresh water." The writer was unable to rear these enchytræids at Woods Hole in the fresh water taken from the laboratory supply. In no case did the worms, when submerged, live more than eighteen hours. However, the addition of a very small amount of sea water to the fresh water made the culture a fairly favorable one.

Lumbricillus lineatus (Müll.)

Identity

The final decision as to the identity of this annelid was reached after the completion of a detailed study of the anatomy and a thoroughgoing examination of the literature dealing with a number of European species which seem to exhibit various degrees of mutual affinity. The complex character of the identification was due to the existence of a number of very similar descriptions of forms under several different names. The writer believes that this study of Woods Hole material has helped to solve some of the difficulties and to establish the identity of certain so-called species. While access to the European material has not been possible, the descriptions, discussions, and figures of the morphology of these foreign forms are sufficiently detailed to serve as a working basis for comparison.

The anatomy of these worms agrees very closely with the description by Moore ('05, pp. 395-397) of a form which he collected at Woods Hole and named *Lumbricillus agilis*. The only points of disagreement have to do with the position of the clitellum, the position and number of the ventral glands, and the character of the spermathecal glands. These matters will be discussed later under their respective headings and the apparent discrepancy accounted for, at least in large part. It will suffice to state here that there seem to be no grounds for a possible suggestion that the material studied by Moore represented a species different from the one examined by the writer.

An inspection of the descriptions of other species ascribed to *Lumbricillus* reveals at least four foreign ones which, as described, approach the Woods Hole form too closely to be disregarded, namely, *litoreus* (Hesse), *lineatus* (Müll.), *subterraneus* (Vejd.), and *verrucosus* (Clap.). That some of the above-mentioned species are not valid has been suspected before. Southern ('09, p. 150) pointed out that the differences between *litoreus* and *lineatus* seemed of no great importance and that it "is doubtful whether there is sufficient justification for keeping the two species apart" and Michaelsen ('01 a, p. 207) has indicated the probability that *lineatus* and *subterraneus* should not be separated. Friend ('16, pp. 23-24), in the examination of specimens from the sewage works of Manchester, England, found that "every intermediate stage" between *verrucosus* (Clap.) and *lineatus* could be detected. With respect to *verrucosus,* the only points of distinction of any importance between it and *lineatus* have been the number of setæ per bundle and character of the ventral glands. A careful parallel column comparison of the characters of all the above-mentioned enchytræids, together with those of the Woods Hole specimens, shows that the range of variability of the body length, setæ, origin of the dorsal blood-vessel, shape of the margins of the brain, dimensions of the spermiducal funnel, and number and development of the ventral glands are such as to link all of these so-called species together. A detailed comparison is out of place here, but reference to the earlier descriptions and a comparison with the following discussion of the morphology of the Woods Hole material will bear out this conclusion.

Since *L. litoreus* (Hesse), *L. subterraneus* (Vejd.), *L. lineatus* (Müll.), *L. verrucosus* (Clap.), and *L. agilis* Moore must all be regarded as the same species, the question arises as to what name shall persist to designate it. It appears that *lineatus* (Müll.) (1771) has priority, but Ditlevsen ('04, p. 431) holds that *lineatus* should give place to Levinsen's name *rivalis* (1884): "Michaelsen hat gewiss recht zu sagen, dass die Art von Levinsen dieselbe wie *Pachydrilus germanicus* Mich. ist; aber nichts in der Beschreibung von O. Fr. Müller berechtigt ihn dazu, diese mit *Lumbricus lineatus* O. Fr. Müller zu identifizieren. Die Charaktere, welche O. Fr. Müller angibt, passen nur gemeinsam auf die Gattung *Pachydrilus*; es ist aber durchaus unmöglich einige ihrer Arten danach zu bestimmen. Da Levinsens Beschreibung die älteste ist, muss die Art den Namen *Pachydrilus rivalis* behalten, und die Art Michaelsens muss dieser zugeordnet werden." The writer has examined the description by O. F. Müller and its vagueness and lack of specific detail is certainly apparent, giving ample reason for the numerous attempts to place this uncertain "*Lumbricus lineatus*." The description might apply to almost any of the species assigned to *Lumbricillus.* On such grounds it might appear that Ditlevsen's contention has some basis but it is evident that, if the synonymy proposed in this paper is correct, the name could not be *rivalis* Levinsen since the name *verrucosus* has priority over it. At the present time there seem to be grounds for regarding *verrucosus* as the valid name, but since some uncertainty still exists concerning some of the other apparently closely related species, the writer prefers to retain, for the present, the old name of *lineatus*.

There is growing evidence that an overindulgence in "species making" has occurred in the genus *Lumbricillus* and the writer is convinced that at least two other so-called species, and probably more, are the same as *lineatus*. The genus needs extensive revision and, when worked over in connection with complete and dependable morphological data, it is very probable that the number of species which the genus is now supposed to contain will be materially reduced.

With respect to the geographical distribution, these annelids have been reported under the old names as follows: *L. lineatus*: Denmark, Germany, North Russia, and England. *L. litoreus*: Italy and Ireland. *L. verrucosus*: Hebrides, Terra del Fuego, Switzerland, Ireland, Scotland, and England. *L. subterraneus*: England, Ireland, Scotland, France, and Bohemia. *L. agilis*: Casco Bay to Vineyard Sound, Mass. Evidently this species is a cosmopolitan form of wide distribution.

HABITAT

In connection with the above rearrangement, it is interesting to consider, under the old names, the habitats from which these animals have been reported. *L. lineatus* has been recorded from debris and under stones on the seashore, or river margins, and on aquatic plants in fresh-water ditches. *L. litoreus* was reported on the seashore under stones. *L. verrucosus* has been found on the seashore under stones, in fresh-water situations, and, with some uncertainty, from earth near manure heaps. *L. subterraneus* has been collected in springs and aqueducts, in sewage works, in streams contaminated with wastes, and on the seashore near high-tide mark. It thus appears that all of the hitherto supposedly different forms occur on the seashore under similar conditions, and in addition certain fresh-water habitats may be occupied, indicating a considerable range of toleration for differences in the presence or absence of salt. In fact, Stephenson ('11, p. 39) found that certain seashore forms from Fintry Bay, which he recorded under the name *L. subterraneus*, "live well for several days in a mixture of equal parts of salt and fresh water, and equally well in altogether fresh water."

Specimens of *Lumbricillus lineatus* were abundant, during July and August, in a number of situations about Woods Hole, frequently intermingling with specimens of *Enchytræus albidus*. In general, the conditions of the habitats of the two species are much the same. Protected coves with sandy, gravelly or rocky, sloping beaches, on which the windrows of eel-grass accumulate near the upper tide limit, provide favorable grounds for these worms. They seem to prefer moderately moist conditions since the larger numbers occur near high-water mark, and seldom at or below the low-tide limit. Their usual position is just below the surface of the moist sand or gravel and there is a distinct tendency to accumulate about the imbedded stones or other larger objects to which they cling closely. Occasionally, just after high tide, specimens may be found on the surface of the sand below the overlying eel-grass which affords a protection against sunlight and retains ample moisture to bridge over the low-tide periods. However, specimens were found on semi-rocky beaches where the eel-grass was quite thin or almost absent but the worms were invariably deeper in the sand. The writer found this worm very abundant in the protected coves in the vicinity of Hadley Harbor. They also occurred in considerable numbers, intermingling with *E. albidus*, on the beach just opposite the Lecture Hall of the Marine Biological Laboratory. The two species can usually be distinguished in the mature stage by the smaller size and particularly by the reddish color of *L. lineatus*, *E. albidus* being invariably milk white. However, it requires more careful scrutiny to distinguish with certainty the immature forms since those of *L. lineatus* are practically colorless.

Methods of Culture

These worms are readily kept alive in the laboratory for indefinite periods by employing the methods already described for *E. albidus*.

MORPHOLOGY

Studies of the external and internal anatomy of these worms corroborate, in most respects, the work of Moore. However, there are some points of disagreement and, in addition, certain structures and organs are described in detail for the first time. Therefore, only those features of the morphology which demand special discussion will receive consideration here and it will be understood that otherwise the findings of the writer are in agreement with those of Moore.

Clitellum.—A well-defined clitellum is present in sexually mature specimens. Moore states that it "extends completely around somites XI and XII." This statement is evidently an error since none of the numerous specimens examined by the writer has the clitellum in that position but instead it occurs on XII and XIII. Its completeness on the ventral side demands some additional description. Transverse sections through the penial bulbs or in their immediate vicinity show the clitellum incomplete on the ventral side but sections cephalad or caudad of the penial bulbs demonstrate that this incompleteness is only partial and that the two ends of the clitellum are continuous, although distinctly thinner on the ventral surface.

Brain.—The description and figure given by Moore ('05, p. 396; fig. 24) present correctly the main features of this organ with the exception that only one pair of supporting strands are represented, those extending from the posterior lobes. In reality, another pair of slender supporting strands extends from the lateral margins, near their middle, diagonally laterad to make attachment with the body-wall. The posterior emargination, the angular form of the posterior lobes bounding the emargination, and the very shallow concave form of the anterior margin seem to be constant characters. The general dimensions of the organ as a whole are subject to some variation, the proportion of the length and width varying from 1.25:1 to 1.75:1.

Spermiducal Funnel.—The spermiducal funnel requires no additional description save in connection with the length. Moore ('05, p. 397) states that this organ is about six to eight times as long as thick. The writer has found considerable variation in the length, depending upon the state of extension or contraction of the animal.

In fully extended specimens, the above-mentioned dimensions are approximately correct, but most of the specimens exhibit funnels the length of which is only about four times the diameter.

Penial Bulb.—The external termination of the sperm duct is described by Moore ('05, p. 397) as opening "into the small, depressed, spheriodal, glandular and opaque atrium, which itself opens on the medial side of a small bursa in the position of the ventral seta. The bursa can be everted as a conical penis." Properly translated into the more modern terminology, the writer finds this very brief description of the penial bulb apparatus to be correct as far as it goes. The term "atrium" is applied to the organ which the writer and others designate as the ***penial bulb,*** atrium being retained to designate the enlargement of the sperm duct which appears in certain genera of enchytræids just entad of the penial bulb. The "bursa" evidently refers to the penial invagination.

Structurally, the penial bulb is simple and conforms to the lumbricillid type. Its transverse diameter is about one-fifth that of the body in the same region. It is approximately globular and enclosed in a thin musculature. The interior is filled with glandular cells of one kind only. They differ somewhat in shape in the different parts of the bulb but in general they are elongate, closely set together, and most of them are arranged radially about the penial lumen. The cells are distinctly nucleated, the nuclei being located for the most part in the peripheral ends of the cells, although they appear in limited numbers nearer the penial lumen and well within the interior of the bulb. The cytoplasm of the bulb cells takes artificial stains with moderate intensity only. The sperm duct unites with the dorsal part of the bulb near the body-wall and the former merges so gradually into the latter that it is not possible to locate exact limits.

Ventral Glands.—These problematical organs, designated in the literature under various names. such as "Kopulationsdrüsen", "copulatory glands", "outgrowths of the ventral nerve cords", "ventral glands", occur in this species but are subject to considerable variation in mature specimens. Well-developed glands occur in XIII and XIV and sometimes in reduced form in XV. Most specimens contain the first two but the one in XV appears only occasionally. The shape and degree of development are also strikingly variable. Specimens were examined in which the glands in XIII and XIV are produced into long wings extending dorso-laterad on either side of the nerve cord, while the one in XV is diminutive and easily overlooked, not extending above the level of the dorsal surface of the nerve cord and developed mainly on one side only. Other specimens show only the gland in XIV well developed and the one in XIII much smaller, both being developed ventrad and laterad of the nerve cord but not into wings, while no gland appears in XV. In all cases, the glands are closely associated with the nerve cord, completely surrounding it except for the median dorsal surface which is exposed. Moore ('05, p. 396) states that the "copulatory supra-neural glands are well developed, especially in somites III, IV and V. They are slender and elongated, not closely united with the ventral nerve, and open on each side nearly at the ventral setæ bundles." The writer has found nothing in III, IV, and V which can be identified as ventral glands, the only thickenings of the nerve cord occurring in those somites being due to the ganglia themselves.

Ovisac.—In the mature specimens in which there is an accumulating mass of developing eggs, the septum XII/XIII is pushed caudad to the posterior part of XIII. Whether this can justly be designated as an ovisac may be open to question, but it probably represents the diminutive "ovisac" reported by Moore.

Spermathecæ.—The spermathecæ are large, well-developed organs lying in the usual position in V. Each is distinctly sigmoid in shape and opens independently into the dorso-lateral aspect of the digestive tract. There is no distinct demarcation between the duct and the ampulla. The latter bears no diverticula, is fusiform in shape, and contains a rather spacious lumen which corresponds to the shape of the exterior. Both ectal and ental openings are distinct and larger than usual. A complete crown of conspicuous glands surrounds the ectal end of the duct and opens into the lumen of the latter at or just entad of the external surface of the body. This crown surrounds practically the whole spermathecal duct, but is not directly united with it except as above mentioned. The ental border of this crown of glands is emarginate at more or less regular intervals, giving it a lobulate appearance and suggesting its origin from a number of glands developed in very close proximity. This crown is made up of a large number of cells and each lobule is also multicellular. It must be noted in this connection that Moore ('05, p. 397) found the ectal end of each spermatheca surrounded by a "circle of glands chiefly aggregated into an anterior and a posterior group." His figure of the same (Fig. 28) shows a very irregular crown of *unicellular* glands, but the writer is inclined to suspect that imperfectly mature specimens might have been studied.

FRIDERICIA RATZELI (Eisen)

Identity

Worms, belonging to this species, were collected from the earth and accumulating humus of the forest floor in Fay's woods, back of the village of Woods Hole. Difficulties arose in connection with the identification of these enchytræids, the chief obstacle being the far too common one, namely, the vagueness and incompleteness of certain European descriptions. A complete morphological study shows that, with one minor exception, there is close agreement with those characters of *Fridericia ratzeli* (Eisen) which have been described, but, unfortunately, the anatomical discussions of the latter fail to give any data concerning the following important features: origin of the dorsal blood-vessel; position of the clitellum; extent and structure of the peptonephridia; the chylus cells; and the structure of the penial bulb. In spite of these deficiencies, there seems no other alternative, at present, than to consider the Woods Hole specimens as belonging to *ratzeli*. The only point of disagreement is the origin of the efferent duct of the nephridium near the posterior end of the postseptal region, instead of near the septum as is described for the foreign specimens of this species. The peptonephridia in the Woods Hole specimens have fewer branches than seem to be called for in the descriptions but it is very doubtful if any significance can be attached to this variation. In addition, the posterior margin of the brain is truncate rather than convex, but such variation is known to occur in other species of Enchytræidæ. It seems, therefore, that the variations presented by the Woods Hole specimens are only of minor importance and not of sufficient weight to demand a different identification. There is, of course, the possibility that when the foreign representatives of *F. ratzeli* receive the much needed intensive morphological study that a varietal difference between them and the specimens from Massachusetts may appear and, in order to facilitate future comparisons, the morphology of the latter will be given in some detail.

It should be noted that the specimens from Woods Hole correspond very closely to an American species, *F. californica,* described in detail by Eisen ('05, pp. 119-121) from specimens collected in the vicinity of San Francisco, although certain points of disagreement appear, such as the origin of the dorsal blood-vessel and the origin of the nephridial duct. The chylus cells and the penial bulb are evidently of the same structure in the California and Woods Hole specimens. The writer is forced to the conclusion that *californica* is identical with *ratzeli,* or if not identical, of no higher rank than that of a variety.

This description records the second appearance of *F. ratzeli* in North America, assuming that the writer is correct in placing *californica* Eisen as a synonym of this species. The two localities represented are separated by the width of the continent but this might be expected since *F. ratzeli* is widely distributed, occurring in England, Ireland, Scotland, Norway, Denmark, Germany, Switzerland, and Italy. The habits of this annelid appear to be much the same in the different parts of its geographical range, being found only in habitats of rich earth or damp moss.

EXTERNAL MORPHOLOGY

The body is elongate, cylindrical, smooth, gradually decreasing in diameter caudad of the clitellum. In nine sexually mature worms, the length varies from 15 to 20 mm., the average being approximately 18 mm. The diameter varies from 0.42 to 0.59 mm. Except in the extreme anterior and posterior ends, the intersegmental grooves are indistinct. The number of somites varies from 55 to 64, the average being 62. A well-developed clitellum occupies XII-XIII. The setæ bundles have the usual characters of the genus *Fridericia.* Anterior to the clitellum, the ventral bundles contain 4-6 setæ, usually 6, while the lateral bundles have a similar number. Caudad of the clitellum, the bundles contain 2-5 setæ, the smaller groups occurring near the posterior extremity. A head pore is present on 0/I and dorsal pores begin on VII. The color of the living specimens was very light yellow to milk white.

INTERNAL MORPHOLOGY

Brain.—This organ occupies a median, dorsal position in I and II, chiefly in the latter. The anterior margin is distinctly convex, the posterior margin truncate, and the lateral margins convex, the maximum width being at a position about two-thirds the total length from the anterior end. The length is about one and one-half times the greatest width, typical measurements being as follows: length, 0.148 mm.; maximum width, 0.104 mm. Two pairs of supporting strands extend from the organ to the body-wall, one from the lateral margins near their middle, and the other from the caudo-lateral angles. The description of *F. ratzeli* based on European specimens calls for a convex posterior margin but since it is known that the brain is subject to change of form under different conditions of contraction and extension, this variation can be of little significance.

Dorsal Blood-vessel.—In the specimens examined, the exact origin of the dorsal blood-vessel is a little difficult to determine. It appears to become distinct from the perivisceral blood-sinus in XX, or in the adjoining somites. The descriptions of *ratzeli* fail to include any statements as to the origin of this vessel in the European specimens. Eisen ('05, p. 120) states that in *californica* it originates in XVI.

Peptonephridia.—A pair of these organs occurs ventrad of the digestive tract, one on the right side and one on the left. Each opens separately into the alimentary canal in the extreme anterior part of V and is confined to that somite. Sparse branching occurs at the base and at the extremity of each. Aside from the branching, the body of each gland is irregularly tuberculate. It is a matter of some difficulty to determine just how closely these organs correspond to the descriptions of foreign specimens of *ratzeli.* Michaelsen ('00, p. 100) states that they are "mehrfach verzweigt". Southern ('09, p. 164) finds them "freely branched" in specimens of *ratzeli* var. *bed-*

dardi from Ireland. Eisen ('05, p. 120) describes them in *californica* as "narrow, slightly and irregularly branched", although his figure (Fig. 81, e) shows more branching than might be inferred from his statement. The peptonephridia are known to be subject to a certain variation within a species and the relatively slight branching in the Woods Hole specimens may merely represent one of the extremes.

Chylus Cells.—The chylus cell region of the intestine occupies XIV-XVI. Cells of two kinds are present, the chylus cells and the ental epithelial cells. The former are somewhat flask-shaped, the broader ends being ectad. The base of each is approximately truncate and the sides converge gradually entad. The ental part of the intracellular canal is usually straight or nearly so, but the basal portion varies somewhat in its course, being usually bent to one side of the cell and then curving abruptly, forming a right angle. The basal part of the canal thus lies more or less parallel to the base of the cell of which it is a part. This intracellular canal is lined by a relatively thick specialized layer of cytoplasm which is everywhere of uniform thickness and structure. The canal is ciliated for a part of its length. A well-developed blood-sinus is present, surrounding the base of each chylus cell and extending up the sides for about two-thirds of its length. A conspicuous nucleus lies in the base of each chylus cell, often a little to one side and in the angle formed by the chief bend of the intracellular canal. The ental epithelial cells lie between the apices of the chylus cells, the ental surfaces bounding a part of the lumen of the intestine and bearing a thickly set coating of elongate cilia. Interstitial cells are absent. The chylus cells are somewhat longer in XIV than in XVI, making the whole layer thicker in the anterior part of the chylus region.

A certain resemblance exists between the structure of the chylus cell region in the Woods Hole specimens and in that described for *californica* by Eisen. The exact position of the chylus cells, the character of the intracellular duct, the general shape and character of the ental epithelial cells, and the relative thickness of the layer are the same, but lack of agreement exists in the California specimens in the restriction of the blood-sinus to the bases of the cells, the close apposition of the cells, and the approximately parallel sides. Chylus cells do not seem to have been described for the European specimens and comparison is not possible.

Nephridia.—The anteseptal and postseptal parts are about the same size although some slight variation occurs in the different somites. The efferent duct arises from the mid-ventral surface of the postseptal part, near the posterior end. Some variation also exists as to the origin of this duct but it was not found farther forward than the middle of the postseptal region. The internal structure is very similar to the usual type found in the genus *Fridericia.*

Foreign specimens of *ratzeli* are described as having the origin of the nephridial duct on the anterior portion of the postseptal part near the septum. Eisen's description of the nephridia in *californica* contains no statement as to the exact origin of the duct but his figure (Fig. 81, a) shows it as arising near the middle of the postseptal region.

Spermiducal Funnel.—A pair of these organs lies in the usual position in XI with the bases close to the ventral part of X/XI and the free extremities directed cephalad. The length of each is about two to three times the maximum diameter. A small, reflected collar is distinctly set off from the body of the funnel by a constriction, its diameter being only about one-half that of the body of the funnel. Each sperm duct is confined to XII and presents a mass of convolutions in the ventral part of the cœlom.

Penial Bulb.—Structurally, the penial bulb is of the lumbricillid type. It is small, compact, globular, and completely invested by a thin but definite musculature which is derived from the muscle-layer of the body-wall. When completely retracted, the invagination is longer than the transverse dimension of the organ, the latter lying completely on the mesal side. The sperm duct unites with the penial bulb on the dorso-ectal surface, penetrating it for a short distance. Within the bulb, it is replaced by the penial lumen, which, curving abruptly laterad, extends to the penial invagination, opening into its ental part. The bulb is composed of cells of but one kind, these being large compared with the size of the organ and distinctly nucleated.

The structure of the penial bulb is similar to that described by Eisen ('05, p. 120) for *californica* in being composed of cells of only one kind, but in the retracted condition, the sperm duct cannot be said to "enter the bulb near the base, splitting the bulb into two unequal parts." Furthermore, if Eisen's figure (Pl. XV, Fig. 9) was made from a transverse section of the worm, a distinct difference appears in the shape of the invagination and the organ as a whole. Mention of the bulb ("prostate") in the descriptions of the European specimens is so brief that little can be done in the way of comparison. It is said to be almost as large as the spermiducal funnel, a proportion which in the Woods Hole specimens would make the bulb several times its present size.

Spermathecæ.—A pair of well-developed spermathecæ is present in V, each organ being composed of three regions: duct, diverticula, and ampulla. The ectal opening of the duct is in the usual position in the lateral aspect of IV/V and has associated with it two small, multicellular, pyriform glands. The ampulla bears on its ectal end a circle of irregular, sessile diverticula, usually eight in number, which vary somewhat in shape but are mostly globular and pendant. Excluding the expanded portion bearing the diverticula, the ampulla is distinctly spindle-shaped. Each ampulla opens independently into the dorso-lateral aspect of the digestive tract. In the sexually mature specimens examined, the ampullæ contained spermatozoa and, in some cases, spermatozoa were not only in the process of passing into the lumen of the alimentary canal, but masses of them were found well within it.

Ventral Glands.—In XIII, XIV, and XV, certain problematical glands occur in connection with the ventral nerve cord. They completely surround the ventral and lateral parts of the latter, leaving only the dorsal surface exposed. At first sight, they appear as unusually developed ganglia, but stained, transverse sections show the tissues of the nerve cord to be distinctly different from those which immediately surround it. These glands are made up of large, nucleated cells, massed irregularly together, which give off processes extending ventrad through the body-wall to the hypodermis. The latter assumes a finely striated appearance with hypodermal nuclei appearing only at irregular intervals. These gland cells are many times larger than the nerve cells immediately above them. The organs are not of uniform size, the one in XIII being larger than the subsequent ones.

Similar glands, described under the various names mentioned on a previous page, occur in certain other genera of enchytræids, namely *Lumbricillus* and *Marionina* (Welch, '14, pp. 150-151), but their appearance in *Fridericia* is quite unusual, being known only in two or three species. Ude ('01, pp. 6-7) found one ventral gland in XIII in the specimens of *ratzeli* which he examined. They have been reported in XIII-XV in *F. antarctica* Bretscher, a synonym, according to Michaelsen ('00, p. 100), of *ratzeli*. *Fridericia dura* (Eisen), another synonym of *ratzeli*, according to Michaelsen ('00, p. 100), but a distinct species according to Ude ('01, pp. 6-7) possesses one ventral gland in XIII.

It should be noted in passing that, in the Woods Hole specimens, superficially similar swellings of the ventral nerve cord occur in II, III, and IV. However, a study of sections through these anterior swellings shows that they are nothing more than ganglionic assemblages of nerve cells and not special masses of gland cells.

SUMMARY

1. The enchytræid fauna of the Woods Hole region, as known at present, comprises three species, *Enchytræus albidus, Lumbricillus lineatus,* and *Fridericia ratzeli*. The first two are marine and occur in great abundance in the inter-tides zone, especially in the protected coves which accumulate windrows of eel-grass. The other species is a terrestrial form, inhabiting the soil and humus of forest land.

2. Both of the marine species can readily be cultured indefinitely in the laboratory by placing them in shallow stender dishes containing a small amount of sea water and pieces of green eel-grass from the drift on shore. They could not be kept alive in the fresh water taken from the Marine Biological Laboratory supply, although when a few drops of sea water were added the unfavorable conditions were relieved.

3. Detailed study of the morphology of the sexually mature *Lumbricillus* yielded evidence that the foreign forms which have been discussed under the names *lineatus, subterraneus, verrucosus,*

and *litoreus* are all one species, and that the American species, *agilis,* originally reported from Woods Hole also has the same fate. These should all be regarded as one species under the name *lineatus* which has priority.

4. *Fridericia ratzeli* has evidently been discovered in North America before, under the name of *californica,* which was applied to specimens found near San Francisco by Eisen. Critical morphological study of the Woods Hole specimens makes it almost certain that *californica* is a synonym of *ratzeli.*

5. All of the three enchytræids herein mentioned are widely distributed in the Old World and evidently so in North America.

6. Morphological detail not readily summarizable are presented for two of the species. Special consideration has been given to the organs of the complex reproductive system, the chylus cells of the digestive tract, and the ventral glands.

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